HPS Software, Monitoring and Data Handling

Maurik Holtrop,
University of New Hampshire

HPS DOE Review, July 11, 2013

HPS Software Group

The software team:

Very active and dedicated people working on the HPS software.

Very strong presence from SLAC group. Framework is SLAC based.

Varied group.

	Institute	Position	Availability
Stacy Karthas	UNH	undergrad.	15%
Sho Uemura	SLAC	grad. student	25%
Omar Moreno	UCSC	grad. student	25%
Andrea Celentano	INFN	grad. student	50%
Sarah Phillips	UNH	post-doc	25%
Per Hansson	SLAC	researcher	13%
Matt Graham	SLAC	researcher	50%
Jeremy McCormick	SLAC	IT professional	15%
Norman Graf	SLAC	Physics staff	15%
Homer Neal	SLAC	Physics staff	10%
Takashi Maruyama	SLAC	Physics staff	25%
Tim Nelson	SLAC	Physics staff	10%
Hovannes Egiyan	Jlab	Physics staff	20%
Krister Bruhwel	Jlab	staff	50%
Ani Simonyan	Yerevan	staff	25%
Nerses Gevorgyan	Yerevan	Physics staff	20%
Raphaël Dupré	Orsay	staff	10%
New Orsay postdoc	Orsay	post-doc	25%
Maurizio Ungaro	Jlab	Staff	10%
Yuri Gernstein+studer	Rutgers	Professor	25%
Maurik Holtrop	UNH	Professor	25%

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Takashi Maruyama	SLAC	Physics staff	25%
Tim Nelson	SLAC	Physics staff	10%
Hovannes Egiyan	Jlab	Physics staff	20%
Krister Bruhwel	Jlab	staff	50%
Ani Simonyan	Yerevan	staff	25%
Nerses Gevorgyan	Yerevan	Physics staff	20%
Raphaël Dupré	Orsay	staff	10%

Software Layout

The HPS software can be seen as three data streams, which have overlapping properties but also distinct features.

Monte Carlo

Generators

↓ StdHep

Detector Simulation

↓ LCIO

Reconstruction

↓ LCIO

DST

Data Analysis

Physics

↓

Detector DAQ

↓ EVIO

Translation layer

↓ LCIO

Reconstruction

↓ LCIO

DST

Monitoring

Detector DAQ

↓ EVIO

Event Transport Ring (ET)

↓ Low level monitoring

↓ Translation layer

↓ LCIO

Reconstruction based monitoring

Monte Carlo Chain

Main Contributors:

Generators

MadGraph/MadEvent, A' signals, tridents
EGS5, beam background
Fluka, pions, neutrons ....

Takashi

StdHep

Detector Simulation

GEANT4 used to simulate detector response:
SLIC, production MC simulation
detector studies, tracking studies...

Jeremy, Sho, Detector groups

GEMC: geometry development, simple PID and trigger studies.

Maurik, Maurizio

LCIO

Reconstruction

hps-java + lcsim, tracking
Ecal cluster & trigger,
JAS3 analysis

Matt, Pelle, Sho, Omar, Kyle, Maurik Jeremy, Norman

LCIO

DST

hps_dst, root analysis

Omar

Data Analysis Chain

Main Contributors:

Physics

↓

Detector DAQ — DAQ produces data in EVIO format. — **Serguei Boiarinov**

↓ EVIO

Translation layer — Convert EVIO data format to LCIO internally in lcsim analysis framework. — **Jeremy, Sho**

↓ LCIO

Reconstruction — hps-java + lcsim, tracking, Ecal cluster & trigger, JAS3 analysis — **Matt, Pelle, Sho, Omar, Kyle, Maurik, Jeremy, Norman**

↓ LCIO

DST — hps_dst, root analysis — **Omar**

↓

Calibration Codes — Tracker, ECAL, Muon calibrations, Detector software alignment. — **Detector Groups**

Eliott Wolin, Carl Timmer

Online Monitoring

Main Contributors:

Detector DAQ — DAQ produces data in EVIO format. — **Serguei Boiarinov**

EVIO

Event Transport Ring (ET) — Distributes data to multiple clients. — **Eliott Wolin, Carl Timmer**

Low level monitoring — Specific programs for monitoring the detector hardware. — **Detector Groups, Stacey, ...**

Translation layer — Convert EVIO data format to LCIO internally in lcsim analysis framework. — **Jeremy, Sho**

LCIO

Reconstruction based monitoring — hps-java + lcsim, tracking
Ecal cluster & trigger,
JAS3 analysis — **Matt, Pelle, Sho, Omar Jeremy, Norman**

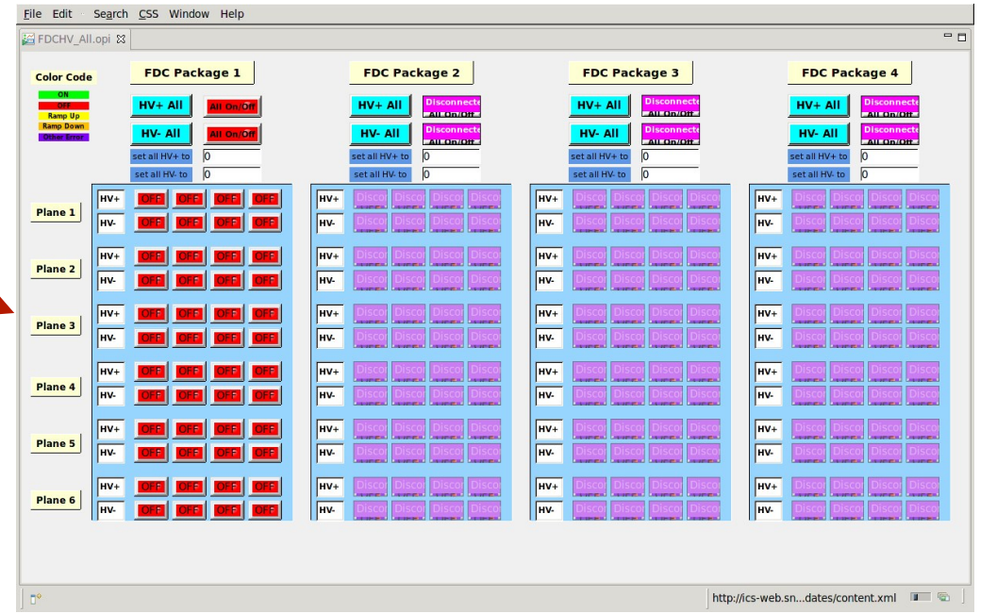
Slow Controls

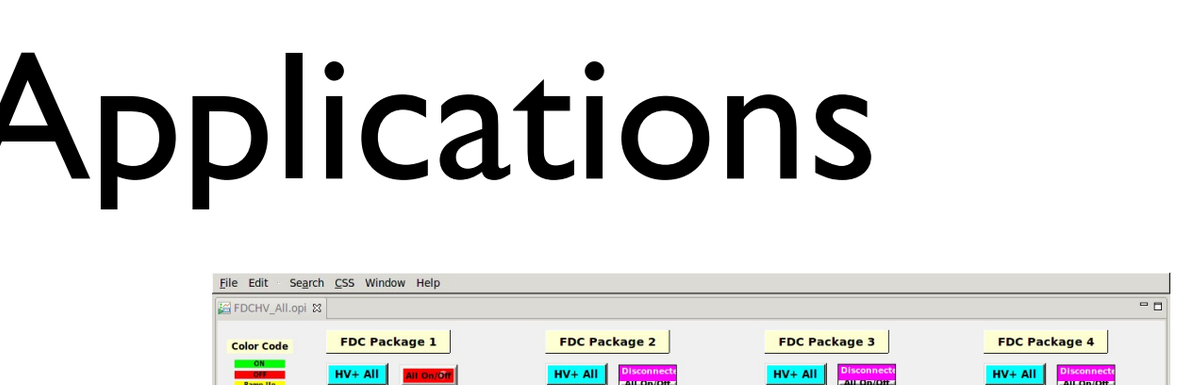
Main Contributors:
Hovanes,
Detector Groups

- A software system separate from the main data analysis chain.
- Used to control and read-back the detector and beam line hardware.
- Uses EPICS: Experimental Physics and Industrial Control System.
  - Free open source software.
  - Familiar at JLab.
- Uses existing MEDM or SSC Boy software extension for visualizations.
- Uses existing Alarm Handler and Striptool
- Database backend for data archiving and connection to reconstruction.

Slow Control Applications

- High & Low voltage control
- Motion control
- Temperature monitoring





- Monitoring of scalers
- Magnet control
- Monitoring of beam line
  - Beam position/current, Harp scans
- Interlocks
  - SVT interlock: temperature, coolant flow, beam quality.

Software Status

- Test run showed we can take data and successfully analyze it.
- Many, many software updates since the test run:
  - MC geometry improvements.
  - Tracking improvements.
  - Analysis improvements.
  - Bug fixes.
- Many further updates (very) desirable.

Updates

- Monte Carlo:
  - Geometry updates: refinements of ECAL and SVT, dead material, (+Muon detector).
  - Event generator tuning (make it faster).
  - Readout refinements (make it even more realistic).
- Data Analysis:
  - Improve tracking - fringe B-field - algorithm refinements.
  - Kalman filter.
  - ECAL cluster finder refinements.
  - (+Muon system readout/reconstruction).
- Monitoring:
  - Fast visual hardware monitor: HPS Event Display.
  - Individual detector monitoring apps.
  - Java reconstruction based monitoring improvements.
- Slow controls:
  - Detailed implementations of controls.

Update Schedule

ID	Task Name	Start	Finish	Work
1	**1 run simulation production**	**Wed 11/20/13**	**Wed 2/12/14**	**480 hrs**
2	1.1 run SLIC	Wed 11/20/13	Wed 1/15/14	320 hrs
3	1.2 run readout sim	Wed 1/15/14	Wed 2/12/14	160 hrs
4	2 ready to run	Tue 2/25/14	Tue 2/25/14	0 hrs
5	**3 primary event generation**	**Mon 7/1/13**	**Fri 8/23/13**	**120 hrs**
6	3.1 tune preselection cuts fo	Mon 7/1/13	Fri 8/23/13	80 hrs
7	3.2 apply multiple scattering	Mon 7/1/13	Fri 7/12/13	40 hrs
8	**4 detector geometry & sim**	**Mon 7/1/13**	**Wed 11/20/13**	**296 hrs**
9	4.1 add muon geometry	Thu 8/1/13	Wed 9/25/13	80 hrs
10	4.2 finalize Ecal geometry (s	Mon 9/9/13	Fri 9/20/13	40 hrs
11	4.3 finalize SVT geometry (a	Tue 8/20/13	Mon 9/2/13	40 hrs
12	4.4 add beamline dead mate	Mon 7/1/13	Fri 7/26/13	40 hrs
13	4.5 compare old and current	Thu 10/24/13	Wed 11/20/13	40 hrs
14	4.6 test 3D field map in SLIC	Mon 7/29/13	Fri 8/23/13	40 hrs
15	4.7 add real 3D field map	Mon 9/2/13	Wed 9/11/13	16 hrs
16	**5 trigger and readout sim**	**Thu 9/26/13**	**Thu 12/19/13**	**320 hrs**
17	5.1 add muon readout	Thu 9/26/13	Wed 10/23/13	40 hrs
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19	5.3 add muon trigger	Wed 11/20/13	Wed 11/27/13	40 hrs
20	5.4 update to reflect FADC/tr	Fri 12/6/13	Thu 12/19/13	40 hrs
21	5.5 add noise/resolution to E	Mon 10/7/13	Fri 10/18/13	40 hrs
22	6 reconstruction ready	Wed 12/25/13	Wed 12/25/13	0 hrs
23	**7 reconstruction**	**Mon 7/1/13**	**Wed 11/27/13**	**840 hrs**
24	**7.1 SVT recon (tracking) im**	**Mon 7/1/13**	**Wed 11/27/13**	**440 hrs**
25	7.1.1 vertexing in B-field	Mon 8/26/13	Wed 10/2/13	40 hrs
26	7.1.2 reorganize tracking	Thu 10/3/13	Wed 10/30/13	40 hrs
27	7.1.3 use single layers for	Thu 10/31/13	Wed 11/27/13	40 hrs
28	7.1.4 kalman filter/GBL	Mon 7/1/13	Fri 9/13/13	160 hrs
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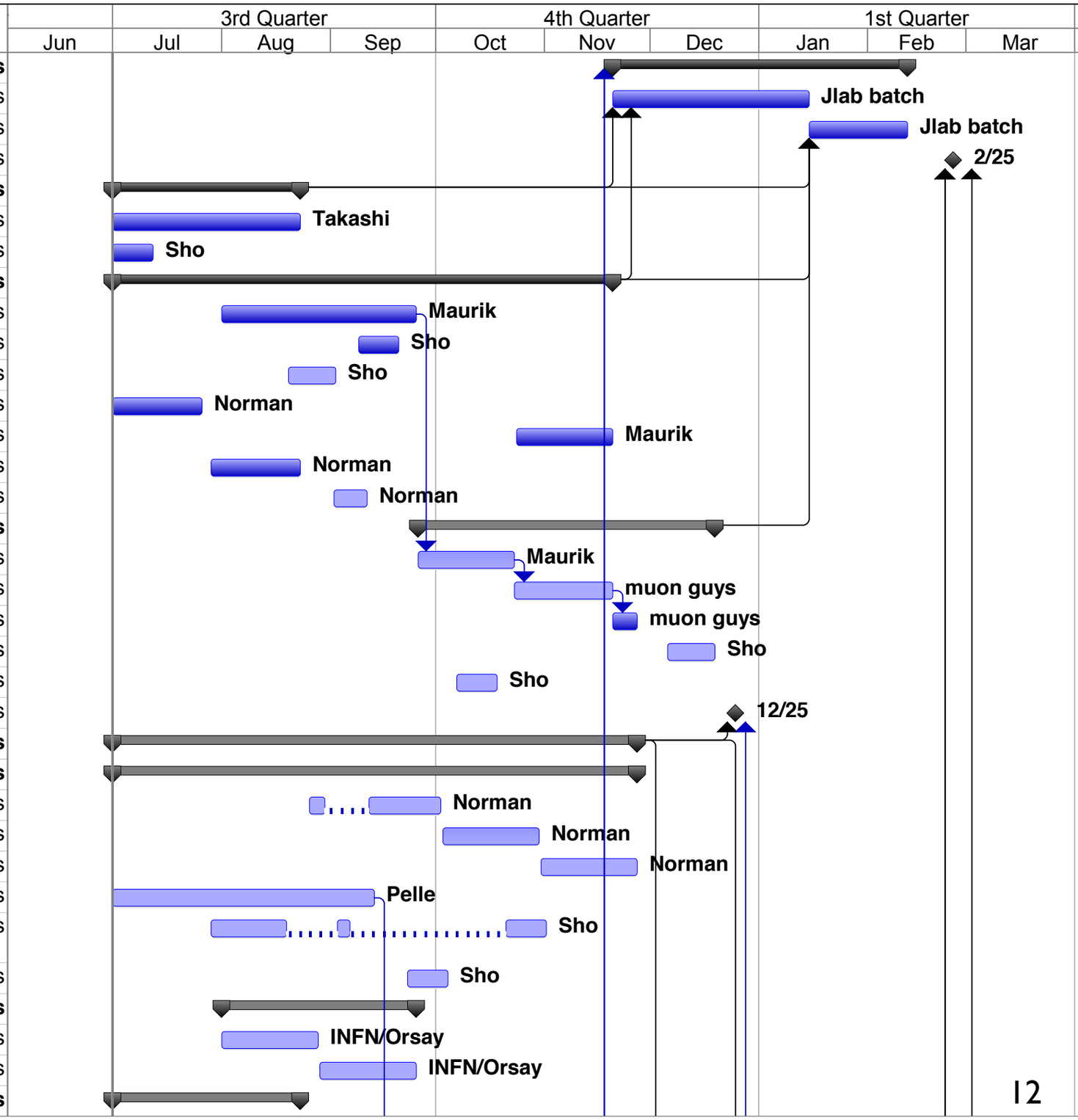

Update Schedule: Analysis

Analysis code improvements already started....

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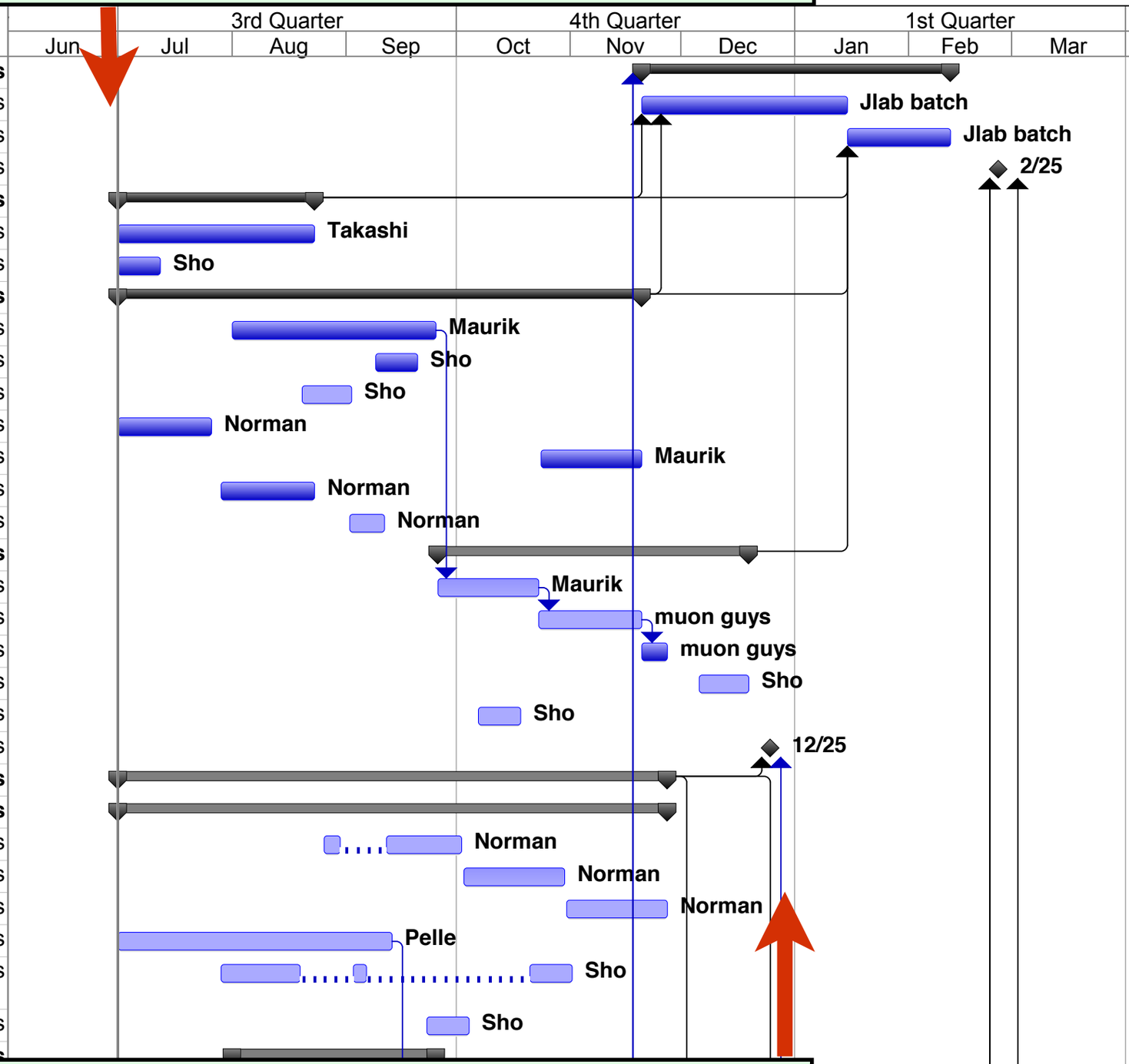

Updates completed end of December.

Update Schedule: Monte Carlo

Simulation Production starting end of November.

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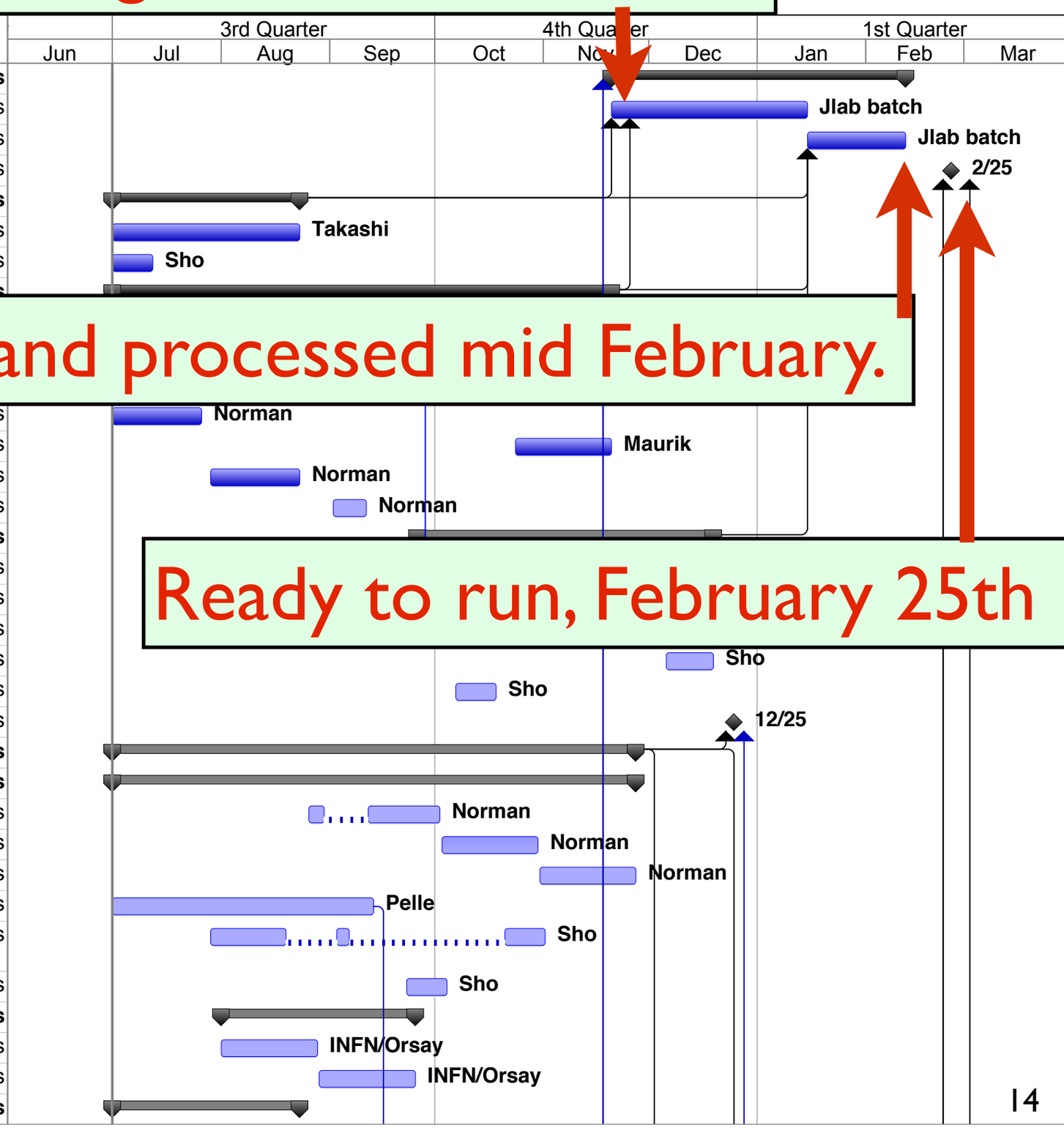
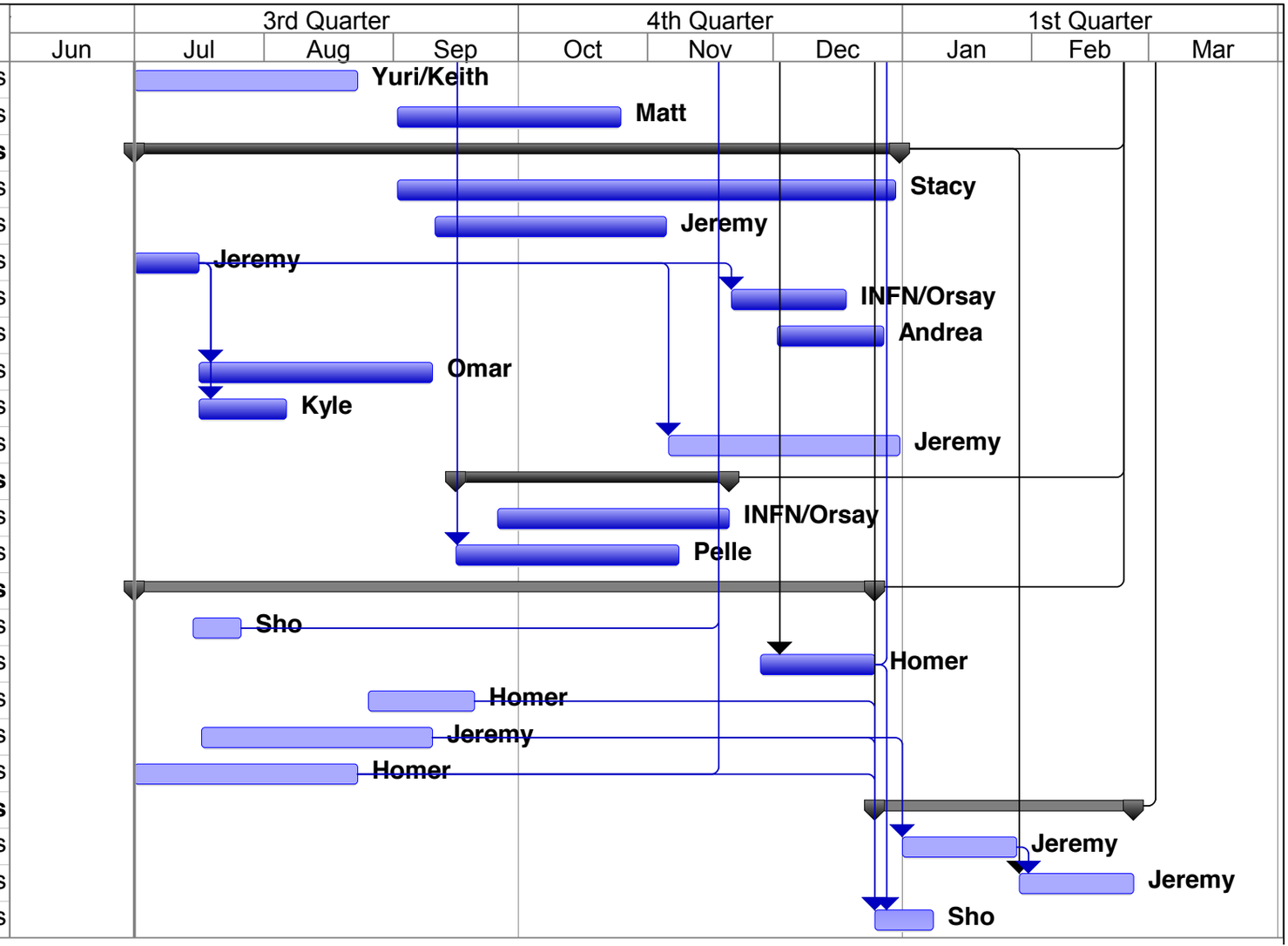


Done and processed mid February.

Ready to run, February 25th

Update Schedule, part 2

ID	Task Name	Start	Finish	Work
35	7.3.1 muon system PID	Mon 7/1/13	Fri 8/23/13	80 hrs
36	7.4 event filtering	Mon 9/2/13	Fri 10/25/13	160 hrs
37	**8 monitoring**	**Mon 7/1/13**	**Tue 12/31/13**	**744 hrs**
38	8.1 "HPSED" (low-level mon	Mon 9/2/13	Mon 12/30/13	120 hrs
39	8.2 Wired event display	Wed 9/11/13	Tue 11/5/13	80 hrs
40	8.3 define interfaces for mon	Mon 7/1/13	Tue 7/16/13	24 hrs
41	8.4 Ecal monitoring	Thu 11/21/13	Wed 12/18/13	80 hrs
42	8.5 Ecal low-level (DAQ) mo	Mon 12/2/13	Fri 12/27/13	80 hrs
43	8.6 SVT monitoring	Tue 7/16/13	Tue 9/10/13	160 hrs
44	8.7 muon monitoring	Tue 7/16/13	Tue 8/6/13	120 hrs
45	8.8 shifter interface, monitori	Wed 11/6/13	Tue 12/31/13	80 hrs
46	**9 calibrations**	**Mon 9/16/13**	**Wed 11/20/13**	**320 hrs**
47	9.1 Ecal calibrations (cosmic	Thu 9/26/13	Wed 11/20/13	160 hrs
48	9.2 track-based SVT alignme	Mon 9/16/13	Fri 11/8/13	160 hrs
49	**10 infrastructure**	**Mon 7/1/13**	**Wed 12/25/13**	**280 hrs**
50	10.1 set up sim production a	Mon 7/15/13	Fri 7/26/13	40 hrs
51	10.2 set up recon production	Thu 11/28/13	Wed 12/25/13	40 hrs
52	10.3 set up DST transfer to S	Mon 8/26/13	Fri 9/20/13	40 hrs
53	10.4 conditions system	Wed 7/17/13	Tue 9/10/13	80 hrs
54	10.5 data catalog	Mon 7/1/13	Fri 8/23/13	80 hrs
55	**11 integration and commissio**	**Wed 12/25/13**	**Tue 2/25/14**	**120 hrs**
56	11.1 integrate monitoring wit	Wed 1/1/14	Tue 1/28/14	40 hrs
57	11.2 commissioning monitori	Wed 1/29/14	Tue 2/25/14	40 hrs
58	11.3 commissioning recon pr	Wed 12/25/13	Wed 1/8/14	40 hrs



Update Schedule: Monitoring

Monitoring codes ready end of December.

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35	7.3.1 muon system PID	Mon 7/1/13	Fri 8/23/13	80 hrs
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37	**8 monitoring**	**Mon 7/1/13**	**Tue 12/31/13**	**744 hrs**
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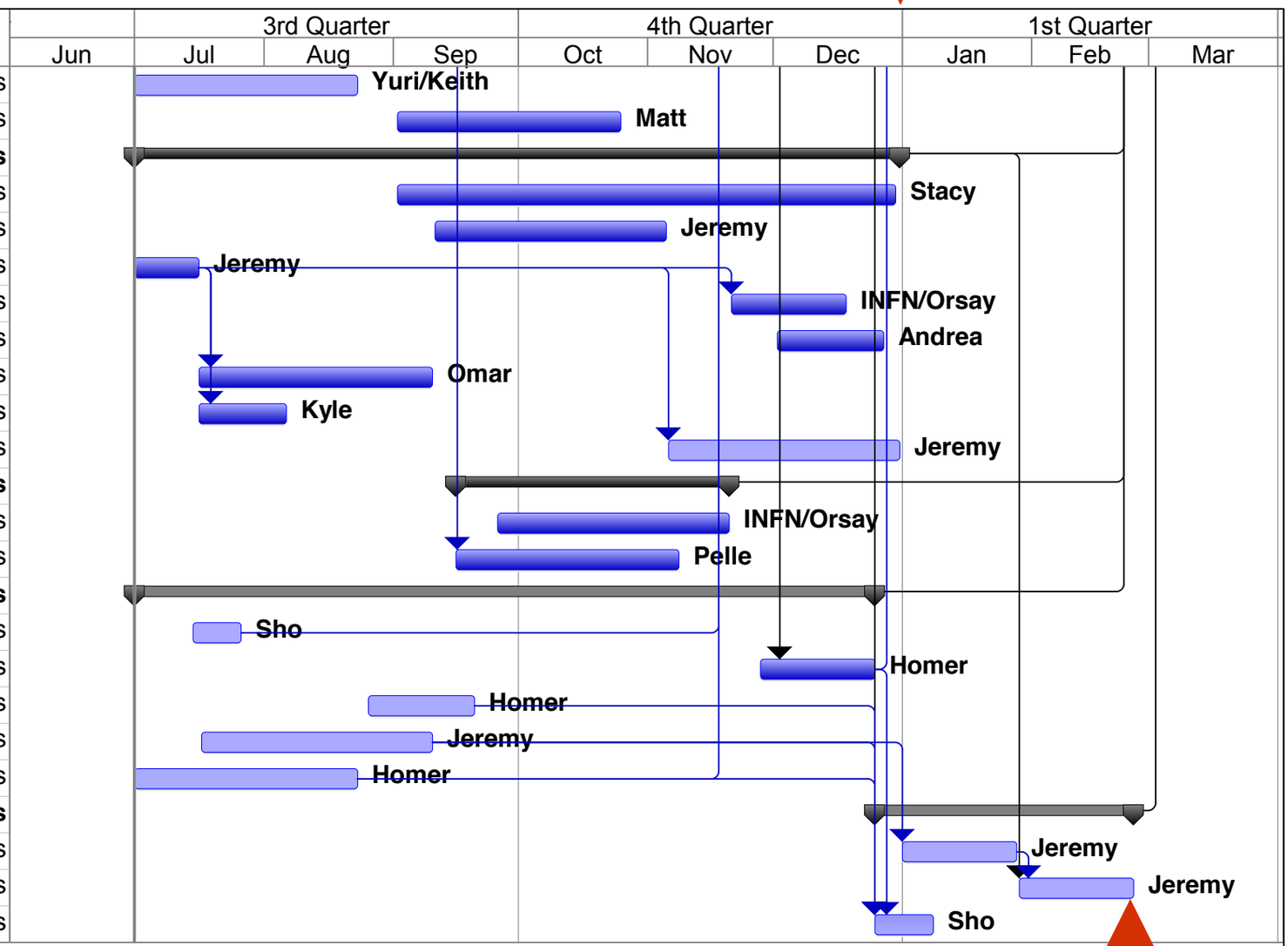
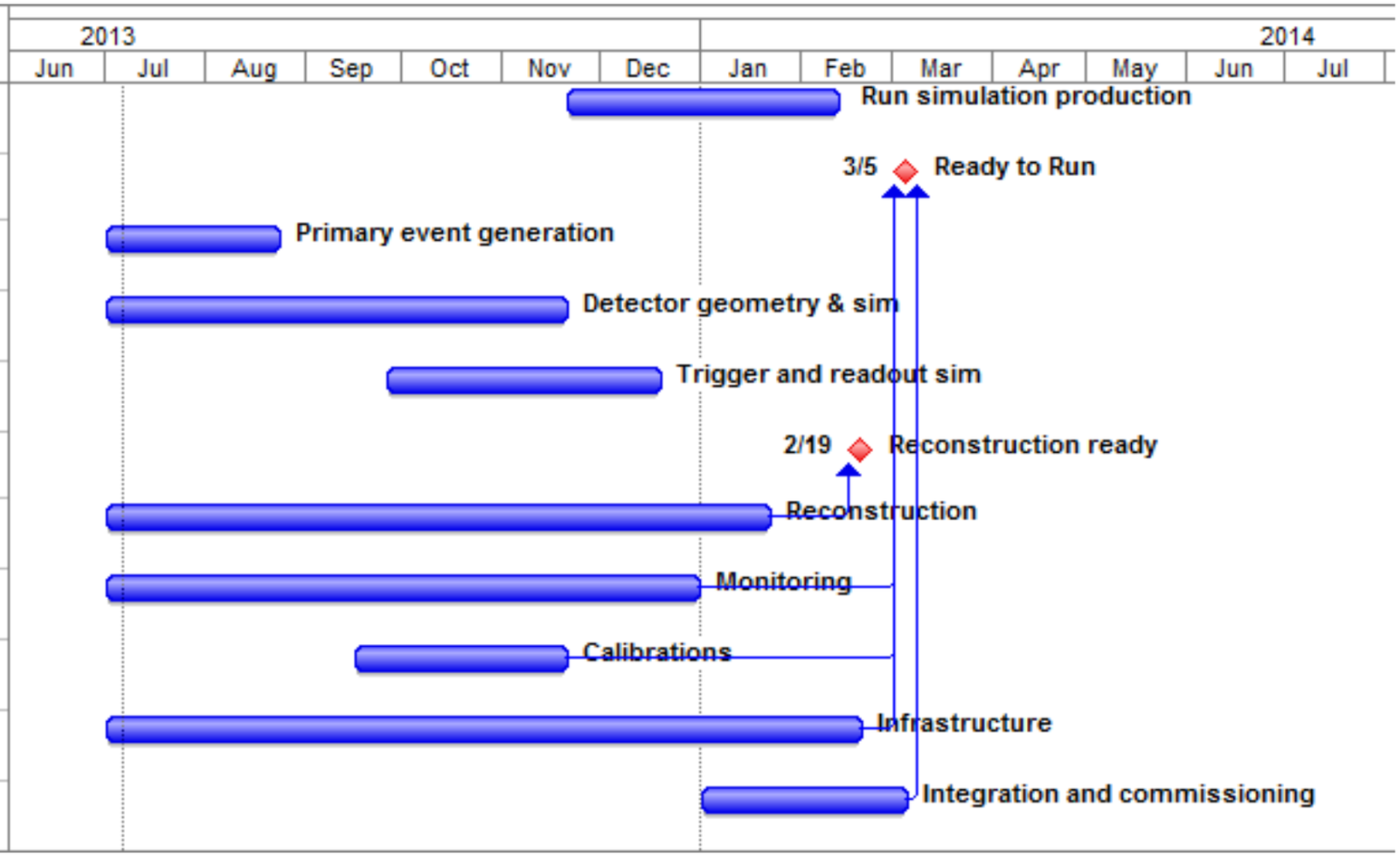


Experimental integration complete, February 25th, 2014.

Update Schedule, Summary

ID	Task Name
1	**1 Run simulation production**
4	2 Ready to Run
5	**3 Primary event generation**
8	**4 Detector geometry & sim**
16	**5 Trigger and readout sim**
22	6 Reconstruction ready
23	**7 Reconstruction**
37	**8 Monitoring**
46	**9 Calibrations**
49	**10 Infrastructure**
55	**11 Integration and commissioning**



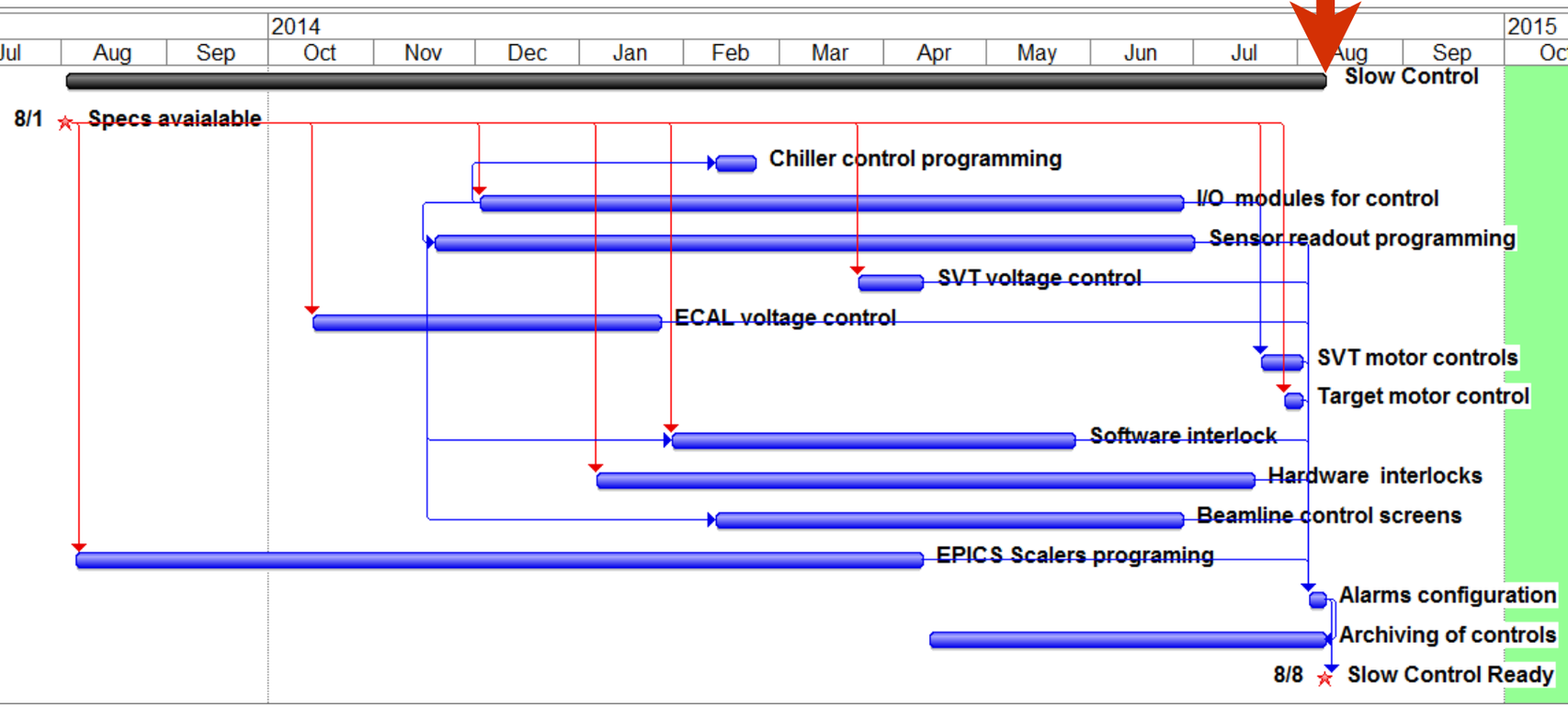
Milestones & Reviews

Reconstruction Ready	19-Feb-14
Ready to Run	**5-Mar-14**

Slow Controls Update

- Slow control updates run separate from main MC, Analysis, Monitoring updates.
- Has dependencies on hardware availability.
- Slow Controls start August 2013.
- **Systems ready August 8, 2014**

WBS	Task Name
1.6	**Slow Control**
1.6.1	Specs avaialable
1.6.2	Chiller control programming
1.6.3	I/O modules for control
1.6.4	Sensor readout programming
1.6.5	SVT voltage control
1.6.6	ECAL voltage control
1.6.7	SVT motor controls
1.6.8	Target motor control
1.6.9	Software interlock
1.6.10	Hardware interlocks
1.6.11	Beamline control screens
1.6.12	EPICS Scalers programing
1.6.13	Alarms configuration
1.6.14	Archiving of controls
1.6.15	Slow Control Ready



	Labor w/ cont.	Material w/ cont.	Total	Capital Eq.
Slow Control	$94	$39	$134	$106

Data storage & handling

- HPS will produce a considerable amount of data.
- Occupancies depend on beam energy, because of small angle multiple scattering.

	Occupancy(%)			Event size (kB)			Data rate (MB/s)		
Beam energy (GeV)	1.1	2.2	6.6	1.1	2.2	6.6	1.1	2.2	6.6
SVT	0.5	0.3	0.3	2.5	1.7	1.5	43.1	27.2	18.9
ECal	3.0	4.2	4.7	0.3	0.3	0.3	4.9	4.8	3.9
Muon	10.0	10.0	10.0	0.2	0.2	0.2	3.8	3.4	2.7
Total		-		3.0	2.2	2.0	51.9	35.4	25.6

- Rates are well within the 100 MB/s limit of DAQ.

Data Storage

Raw data will be stored and then processed offline.
Processed data contains more information, increasing event size by about 4.5x.
MC data will be 10% of the number of events.
MC event size is much larger, so total storage space is significant.

Run	E_{beam} (GeV)	Time (days)	Events ($\times 10^9$)	Raw data (TB)	Processed data (TB)
2014	1.1	21	33	100	445
2014	2.2	21	29	63	282
Total	-	42	62	**163**	**727**
2015	2.2	35	48	105	470
2015	6.6	35	38	76	341
Total	-	70	86	**181**	**810**

Data and MC produced and stored at Jlab

Storage category	2014 (TB)	2015 (TB)
Raw data	163	181
Processed raw data	727	810
Simulated data	965	1244
Total tape space	**1855**	**2236**
Disk space	100	100

Data Processing and MC

- Analysis of data events is expected to take 0.1 CPU-sec.
- MC of average of beam background event: 0.02 CPU-sec.
- MC of A' event: 0.7 CPU-sec.

Computing category	2014	2015
Raw data processing	1.7 M CPUh	2.4 M CPUh
Simulation production	8.8 M CPUh	10.1 M CPUh
Total	**10.5 M CPUh**	**12.5 M CPUh**

(* Times on standard Jlab compute core.)

Computing requirements are within Jlab capabilities.
Disk space and processing time will be requested from Jlab.

Conclusions

- HPS has a very dynamic and active software group.
- Most desirable updates of software are on a well on track.
- Test run shows we are capable of taking and processing the data.
- Software is difficult to schedule,
  but we have a good safety margin.
- There are always further improvements possible, we won't stop.
- Data processing and storage space are within Jlab capabilities.

Backup.

Data production

Estimated amounts of data produced for 2014 and 2015 run periods.

Run	E_{beam} (GeV)	Time (days)	Events ($\times 10^9$)	Raw data (TB)	Processed data (TB)
2014	1.1	21	33	100	445
2014	2.2	21	29	63	282
Total	-	42	62	163	727
2015	2.2	35	48	105	470
2015	6.6	35	38	76	341
Total	-	70	86	181	810

MC Data size

- An MC event stores more information than a raw data event. This is carried forward with the processed data to allow for full analysis of the events.

Event type	Sim. stage	Size/triggered event (kB)	Mass points
Beam bkg.	evgen	37.0	1
A' signal	evgen	0.5	10
A'+beam bkg	evgen	37.4	10
Beam bkg.	MC output	79.5	1
A' signal	MC output	2.5	10
A'+beam bkg	MC output	82.0	10